PATENT

Device For Simulating Some Aspects Of Cigarette Use

1. Field of the Invention

The present invention relates generally to the field of smoking simulators, and more particularly to the field of devices which demonstrate to teenagers the loss of control over their lives caused by the habit of smoking cigarettes.

2. Description of Related Technology

Cigarette smoking is an addictive habit which is extremely difficult to break. The harm to a person's health caused by smoking is well documented. Furthermore, the habit is costly to support even if the user is not a heavy smoker. Numerous devices have been developed to help smokers quit, such as United States Patent No. 3,999,412, issued to Boroski et al. The Boroski et al. device is a cigarette case which counts and rations the number of cigarettes dispensed to the user.

Various smoking elimination systems utilize a timer which establishes a basic timing period during which a cigarette case or lighter is locked. These patents include U.S Patent No. 3,744,953, issued to Herr, U.S. Patent No. 2,681,560, issued to Shuttleworth et al. and U.S. Patent No. 2,643,527, issued to Harris. When the basic timing period is over, the cigarette lighter or box may be opened to permit a single use of a cigarette. Sometimes the timing period is manually adjustable and generally the timer must be manually reset each time a cigarette is removed from the case or a cigarette lighting operation takes place. In such a smoking elimination system, each time the user desires to smoke, she must try to operate the cigarette lighter or open the cigarette case to determine whether or not she can smoke. A related device is disclosed in U.S. Patent No. 3,424,123, issued to Giffard, in which the lock is eliminated and a bell signals the user that the basic timing period has expired.

Other more interactive programmable devices have been developed to assist, monitor, control or record various types of human behavior. U.S. Patent No.4,100,401, issued to Tutt et al. discloses a device that permits a user to input data representing caloric intake as well as expected caloric expenditure rates. The device then displays the instantaneous net balance of unconsumed calories. The Tutt et al. device does not generate any personalized program for behavior modification or any personalized programmed schedule of future event times. U.S. Patent No. 4,144,568, issued to Hiller et al. discloses a device which records various personalized data and provides related output data to the user. While the output data may be of interest to the user and might conceivably affect the user's future activities, the Hiller et al. device does not actually stimulate human behavior modification in any meaningful sense.

U.S. Patent No. 4,281,389, issued to Smith describes a device which is programmed to provide personalized metronome like audible signals designed to pace every other stride of a long distance runner. The necessary data may be manually input prior to the run, or the runner may manipulate manually accessible controls and modify the programming so as to conform with her actual stride frequency during a given run. Thereafter, the device is capable of providing a modified programmed stride rate so as to signal the stride rate required to achieve a desired run time.

U.S. Patent No. 4,360,125, issued to Martindale et al. shows a medicine dispenser which signals the user each time a medication event is supposed to occur and also records the time at which each medication access by the user actually occurs. The device only provides a health care worker with such a factual record and no attempt is made to create any modified program schedule for the future. U.S. Patent No. 4,428,050, issued to Pellegrini et al. discloses a device which accepts personalized data relating to skin tanning parameters and then provides the user

with a program which should be followed so as to achieve a desired degree of tanning. There is no baseline learning phase, nor is the device directed toward modification of habitual human behavior associated with a sequence f events.

U.S. Patent No. 4,853,854, issued to Behar et al., discloses a behavior modification device to help a user quit smoking. The device is a small pocket sized device that is controlled by a microprocessor programmed in read only memory with a specific control program. When a user activates the device by means of an external switch, the device begins a baseline establishment phase of the behavior modification process. Each time the user performs a habit related event, the user informs the device through the use of a switch. The device records the event at the time of its occurrence for future processing. The device remains in the baseline phase for a predetermined period of time. When the baseline period ends, the device notifies the user and proceeds to the withdrawal phase of the program. Once the personalized withdrawal phase occurs, the device prompts the user by providing visual and audio stimuli as to when the user may smoke one cigarette. A visual display also informs the user as to when permission to smoke again will be granted. The user notifies the device that the prescribed event has been committed by activating a switch.

Some devices exist which require a user to actually exhale into a handheld unit. An example of such a device is disclosed in U.S. Patent No. 5,291,898, issued to Wolf. The Wolf device is a breath analyzer which contains a tube into which a user exhales, the breath sample being analyzed for its alcohol content.

While some of the aforementiond devices deal with smoking and behavior modification, none address the problem of preventing a person from smoking who has never engaged in the habit. Further, none of these devices are actuated in a manner that attempts to accurately simulate the actual act of smoking. For example, none of the prior art devices simulate the spending of money to purchase

cigarettes, cause the user to crave a cigarette at inconvenient times due to nicotine addiction or simulate coughing caused by long term cigarette use.

Summary of the Invention

The present invention is a device which demonstrates to prospective smokers, who are most likely teenagers, the loss of control over their lives caused by smoking. The device is preferably a box which has the same dimensions and appearance as a package of cigarettes. The box contains a microprocessor connected to a liquid crystal display which displays messages to the user, or preferably a voice recognition and synthesis circuit to permit spoken interaction with the device. The device gives orders to the user which simulate the effects of smoking while monitoring the user's responses. The device also presents the user with general information relating to the disadvantages of smoking and emphasizes the control that the habit of smoking can exert on the user's life.

The simulator also includes a vibrator and speaker or beeper to prompt the user to read the LCD display. A bellows switch is included to detect the action of the user inhaling or exhaling through a tube to simulate the drawing in of air through a cigarette and the need to catch one's breath after each draw. The tube is replaceable to permit the use of the simulator by different users. Occasionally the device will cough or the user will be prompted by the device to cough and the act of coughing is detected by a built in microphone.

In order to simulate the expense associated with the habit of smoking, a slot can be formed in the side of the simulator box which is sufficiently large to accept a dollar bill or suitable money substitute. A microswitch is placed within the cavity to detect when a dollar bill is actually inserted into the simulator. In a classroom environment, the currency accepting cavity can be opened by a key which is in the possession of the teacher. The times when the student is both permitted to smoke or

required to smoke can be programmed into or calculated by the unit, and a pushbutton on the outside of the device can toggle through a choice of such time periods in, for example, five minute increments.

In one preferred embodiment of the device, the smoking simulation program which can be experienced by use of the device will last approximately three days. The first day simulates the demands of smoking approximately one half of a package per day. The second day simulates about one pack per day. The third day of the simulation approximates the use of two packs per day. The messages displayed by the device, which can include both requests and information, become increasingly demanding and onerous as the simulation progresses. Ideally, the simulator is capable of delivering hundreds of such messages in order to maintain the user's interest. When the program is complete, the student has gained a better understanding of the expense and inconvenience of smoking. The device is capable of storing various parameters related to the student's interaction with the device, and these parameters can be reviewed by the teacher in order to evaluate the level of the student's performance.

Brief Description of the Drawings

Figure 1 is a front elevation of a smoking simulator constructed according to the principles of the present invention;

Figure 2 is a side elevation of the apparatus depicted in Figure 1;

Figure 3 is a plan view of the apparatus depicted in Figure 1;

Figure 4 is a schematic diagram of a portion of the present invention which includes a microprocessor and random access memory;

Figure 5 is a flow chart depicting the general operation of the present invention;

Figure 6 is a flow chart depicting the powerup and initialization portion of the software depicted in Figure 5;

Figure 7 is a flow chart portraying the "Teacher Interrupt" portion of the software referred to in Figure 5;

Figure 8 is a flowchart of a portion of the present invention which portrays the RUN subroutine;

Figure 9 is a flowchart of a portion of the present invention which portrays the SMOKING NOTIFICATION subroutine;

Figure 10 is a schematic diagram of a preamplifier and power supply constructed according to the principles of the present invention;

Figure 11 is a flowchart depicting the INFORMATION NOTIFICATION subroutine utilized by the present invention;

Figure 12 is a side sectional view of one embodiment of a puff receptacle and sensor associated with the present invention;

Figure 13 is a perspective view of a second embodiment of a puff receptacle associated with the present invention;

Figure 14 is a flowchart depicting the COUGHING INTERRUPT subroutine utilized by the present invention;

Figure 15 is a flowchart depicting the STUDENT PUSHBUTTON INTERRUPT subroutine associated with the present invention;

Figure 16 is a flowchart depicting the SMOKING ACTION subroutine utilized with the present invention;

Figure 17 is a flowchart depicting the BUM CIGARETTES subroutine which forms a part of the present invention; and

Figure 18 is a flowchart depicting the INFO ACTION subroutine utilized during operation of the present invention.

Detailed Description of the Preferred Embodiments

Nomenclature

1 Smoking simulation apparatus

2	Case
3	Edge
4	Hinge
5	Surface
6	Lid
7	Rear Surface
8	Receptacle
9	Speaker
10	Microphone
11	Recess
12	Switch
13	Perforations
14	Front
15	Display Window
16	Earphone Jack
17	Puffing Device
18	Side
19	Microcontroller
20	Random Access Memory
21	Data D7 pin 2
22	Data D6 pin 3
23	Data D5 pin 4
24	Data D4 pin 5
25	Data D3 pin 6
26	Data D2 pin 7
27	Data D1 pin 8
30	Data D0 pin 9
32	Visual Display
33	Core Ground pin 33
34	Core Power supply input pin 34

35 I/O 1.7 pin 35

36 I/O 1.6 pin 36

37 I/O 1.5 pin 37

38 I/O 1.4 pin 38

39 I/O 1.3 pin 39

40 I/O 1.2 pin 40

41 I/O 1.1 pin 41

42 I/O 1.0 pin 42

43 I/O 0.7 pin 43

44 I/O 0.6 pin 44

45 I/O 0.5 pin 45

46 I/O 0.4 pin 46

47 I/O 0.3 pin 47

48 I/O 0.2 pin 48

49 I/O 0.1 pin 49

50 I/O 0.0 pin 50

51 Memory Data port D0 pin 13

52 Memory Data port D1 pin 14

53 Memory Data port D2 pin 15

54 Memory Data port D3 pin 17

55 Memory Data port D4 pin 18

56 Memory Data port D5 pin 19

57 Memory Data port D6 pin 20

58 Memory Data port D7 pin 21

59 Data bus

60 Address Bus

61 Address Line A1 pin 26

62 Address Line A2 pin 25

63 Address Line A3 pin 24

64 Address Line A4 pin 23

65 Address Line A6 pin 21

66 Address Line A7 pin 20

67 Address Line A8 pin 17

68 Address Line A9 pin 16

69 Address Line A10 pin 15

70 Address Line A11 pin 14

71 Address Line A12 pin 13

72 Address Line A5 pin 22

73 Address Line A 13 pin 12

74 Address Line A14 pin 11

75 Address Line A15 pin 10

76 Address Line A0 pin 27

77 Power Supply

78 Analog Power Supply

79 Battery

80 Capacitor

81 Diode

82 Air Jets

83 Resistor

84 470 microfarad capacitor

85 Audio Preamplifier

86 Terminal

87 Core Power Supply

88 2.2 ohm resistor

89 Electrolytic Capacitor

90 Input/Output Power Supply

91 Resistor

92 Capacitor

93 Resistor

94 Capacitor

95 Reset Terminal

96 Diode

97 Bandpass Filter

98 Automatic Gain Control Circuit

99 IGAIN0 Terminal

100 IGAIN1 Terminal

101 1000 ohm resistor

102 22000 ohm resistor

103 10000 ohm resistor

104 First Stage amplifier

105 Third Stage amplifier

106 0.22 picofarad capacitor

107 4700 ohm resistor

108 680000 ohm resistor

109 27000 ohm resistor

110 1000 ohm resistor

111 0.22 picofarad capacitor

112 Fourth Stage amplifier

113 56000 ohm resistor

114 1000 ohm resistor

115 Low Analog Output terminal

116 High Analog Output terminal

117 Digital Ground Pin18

118 Digital Power supply input pin 19

119 Digital Ground Pin 52

120 Digital Power supply input pin 51

121 0.1 microfarad capacitor

122 Digital Ground

123 Core Ground input pin 1

124 Core Power supply input pin 68

125 0.1 microfarad capacitor

126 0. 1 microfarad capacitor

127 Core ground

128 Core ground

129 Surface

130 Analog ground input pin 64

131 Analog power input pin 67

132 0.1 microfarad capacitor

133 Analog ground terminal

134 14.3 MegaHertz crystal

136 27 picofarad capacitor

137 27 picofarad capacitor

138 Oscillator 1 ouput pin 30

139 Oscillator 1 input pin 31

140 32.768 KiloHertz crystal

141 27 picofarad capacitor

142 27 picofarad capacitor

143 Oscillator 2 input pin 28

144 Oscillator 2 output pin 29

145 Read Code pin 53

146 Write Code pin 54

148 Read Data pin 55

149 Write Data pin 56

150 74HCT08 integrated circuit

151 Chip Enable pin 22

152 Output Enable pin 24

153 Write Enable pin 29

154 Pulse width modulation output pin 66

155 Pulse width modulation output pin 65

156 Input/Output port 0.0 pin 50

157 Input/Output port 0.1 pin 49

158 Input/Output port 0.2 pin 48

159 Input/Output port 0.3 pin 47

160 Microswitch

161 Bellows Switch

162 Sound Activated Switch

163 Pushbutton

164 Flow restrictor

165 Puffing device

166 Mounting Bracket

167 Check Valve

168 Filter

169 Overview Flowchart

170 Powerup and Initialize

171 Run

172 Bootup procedure

173 Password request and store

174 Sleep mode

175 Voice verification

176 Time Entry prompt

177 Clock Startup

178 Teacher Prompt

179 Pushbutton

180 Teacher Interrupt

181 Wakeup from sleep

182 Request prompt

183 Report Command

184 Run Command

185 Buy Cigarettes Command

186 Packs Per Day Command

187 Escalation Rate Command

188 Metabolic Rate Command

189 Susceptibility Command

190 Information Frequency Command

191 Set Number of Packages

192 Initial Smoking Rate

193 Escalation Rate

194 Metabolic Rate

195 Susceptibility

196 Information Rate

197 Return Path

198 Verification of Password

199 Brand Selection

200 Personality

201 Physiological Parameter Calculations

202 Nicotine Craving Level

203 Smoking Action Module

204 Internal Timers

205 Smoking Notification Module

206 Notification Methods

207 Device Scheduler

208 Information Notification Module

209 Notification Options

210 Notification Timer

211 Coughing Interrupt Module

212 Notification Methods

213 Cough Prompt

214 Retry Option

215 Record Success

216 Record Failure

217 Student Command

218 Random Number Generator

219 Belligerence Path

220 Repetition Step

221 Cooperation Path

222 Borrowing Module

223 Information Action Module

224 Inventory Inquiry

225 None Available Announcement

226 Smoking Permitted Announcement

227 Continuous Listening Subroutine

228 Consumption Rate Calculator

229 Return path

230 Counter

231 Demand

232 Message Bank

233 Message Generator

234 Sound Monitor

235 Interrogatory

236 Record Failure

237 Deathclock monitor

238 Recorder

239 Cigarette Inventory

240 Question

241 Failure Path

242 Listen

243 Recognition

244 Playback

245 Decrement

246 Loop

247 Tone Recognition

248 Increment

249 Question

250 Listening Interval

251 Correct Answer

252 Correct Register

253 Incorrect Register

254 Dollar Bill Slot

Referring to Figures 1, 2, 3 and 12, a smoking simulation apparatus **1** is shown which is housed in a case **2** which approximates the rectangular shape and dimensions of a package of cigarettes. The case **2** is formed of a plastic or metallic material and houses the mechanical and electrical components which comprise the active components of the device. Analogously, the embodiment for other drug deterrence purposes might take the form of a package of hypodermic needles or other drug-related paraphernalia. The intent is to provide some sense of connection in the mind of the user between the deterrence device and the addiction or habit being deterred.

On the front **5** of the enclosure **2** are grills for the speaker **9** and microphone **10**, which are mounted inside. The grill for the microphone consists of two parts. First there is the central receptacle **8** for the straw portion of the simulated cigarette to fit into. This is the also primary opening for the microphone **10** to listen to speech and other sounds from the outside world. Second, the peripheral holes **13** surrounding the central receptacle **8** form jets of air **82** which impinge on the microphone **10** when the user puffs through the simulated cigarette **17**. The jets of air **82** impinging directly on the microphone **10** create a relatively loud white noise which is recognizable as a puff by the sound recognition software.

An alternative embodiment also includes an LCD alphanumeric or graphics display **32** for communicating silently to the user. The LCD display might show a

pictorial representation of a cigarette as it is being smoked by the user, showing it getting shorter. Simultaneously, the LCD might show a deathclock, showing average life expectancy lost if present rate of smoking continues, counting up in realtime as the user smokes. And the LCD can display textual information to the user, educating them on other aspects of smoking.

The top **6** of the enclosure flips opens like a hardpack of cigarettes. Inside the top of the enclosure are pushbuttons for the user (student) **163** or supervisor (teacher) **179** to wake up the microprocessor. There is also an earphone jack **16** for communicating without disturbing those in the vicinity (such as in a classroom). The fliptop **6** also protects the buttons **163, 179** from being pressed inadvertently, and keeps the earphone jack **16** clean of dirt or pocket lint, since the device **1** is intended to be carried in a shirt pocket or purse.

The side **18** of the enclosure **1** has a recess **11** to hold a simulated cigarette or puffing device **17**. The puffing device **17** is held externally so its storage area **11** can be easily cleaned with an alcohol swab for sanitary purposes.

Referring also to Figure 13, the puff device **17** with flow restriction **164** . The simulated cigarette or puffing device **17** has three main features: (a) A straw **165** that fits into the receptacle **8** on the enclosure **1**, (b) A check valve **167** that prevents the user from blowing into the receptacle **8** and to keep the receptacle **8** clean for sanitary reasons, and (c) A fixed or removable filter **168** that acts as a flow restriction to simulate actual puffing resistance of typical cigarettes, as well as puffing difficultly caused by lung disease. A similar straw can also simulate inhaling cocaine and methamphetamines. An alternative embodiment for deterring other drugs replaces the simulated cigarette with a simulated hypodermic (without the needle) that emits an inaudible but recognizable whistle when "injected". The microphone **10** and software would hear and recognize the whistle and record that sound as an injection event.

Referring to Figure 4 some of the electronics of the present invention **1** can be appreciated. The simulator **1** is capable of both sensing sounds made by the user, such as coughing and inhaling, as well as generating spoken messages which instruct the user of the device. The speech recognition and speech synthesis functions are performed by integrated circuit **19,** which is preferably an RSC-164 microcontroller and speech processing circuit manufactured by Sensory, Incorporated, 521 East Weddell Drive, Sunnyvale, California 94089. The specific function and features of circuit **19** are more fully described in United States Patent No.5,790,754, issued to Mozer et al The circuit **19** is powered by three isolated power supplies and ground reference levels. Digital power source **90** supplies digital Input/Output pins **117, 118 119** and **120.** Filtering is accomplished by capacitor **121** and digital ground connection **122.** Core power supply **87** supplies core processing via pins **33, 34, 123** and **124.** Filtering is accomplished by capacitors **125** and **126,** and core ground connections **127** and **128.** Analog power supply **78** furnishes power for audio processing via pins **130** and **131.** Filtering is accomplished by capacitor **132** and ground connection **133.** Processing speed is controlled by a high speed oscillator network composed of crystal **134,** capacitor **136** and capacitor **137,** which is connected to oscillator pins **138** and **139.** A low speed oscillator network consisting of crystal **140** and capacitors **141** and **142** is attached to microcontroller **19** pins **143** and **144.**

The circuit **19** includes sixteen general purpose Input/Output ports **35-50.** Each pin can be programmed as input with a weak pull up, an input with a strong pull up, an input without pull up or as an output. Microcontroller **19** also includes an external memory interface that allows connection to a standard nonvolatile static random access memory chip **20.** Microcontroller **19** includes separate read and write signals for each external memory space. Microcontroller **19** is constructed with eight data input/output lines **21-27** and **30,** which are interconnected to the corresponding data input/output lines **51-58** via data bus **59.** Addressing is accomplished along address bus **60.** In this particular use of the microcontroller **19,** nineteen address lines (**61-76** and **40-42**) are used to address 512 kilobytes of memory stored in memory chip **20.** The nineteen

address lines are connected to pins **A0-A18** of memory chip **20.** The microcontroller **19** controls memory access via pin **145** (read code), pin **146** (write code), pin **148** (read data) and pin **149** (write data). These pins are ANDED together by chip **150** to provide appropriate logic control to control memory chip **20,** the latter being controlled by pin **151** (chip enable), pin **152** (output enable) and pin **153** (write enable). The data written to or received from memory chip **20** is transferred via the data bus **59** to connecting pins **D0-D7** of microcontroller **19** and connecting pins **51-58** of the memory chip **20.** Audio output is provided via speaker **9** which is attached to the pulse width modulation output pins **154** and **155** of the microcontroller **19.**

Referring to Figure 10, the power supply **77** includes three separate power supply elements. The analog power supply **78** receives its input power from system battery supply **79** which is preferably formed from three "AAA" alkaline batteries wired in series. Capacitor **80** and diode **81** form a half wave rectifier or filter which also protects the remaining circuitry against incorrect (reverse polarity) battery insertion. Analog power supply **78** is isolated and filtered by resistor **83** and capacitor **84.** The analog power supply **78** provides power to audio preamplifier **85** via terminal **86.** The core power supply **87** is isolated and filtered by resistor **88** and capacitor **89.** Core power supply **87** provides power to microprocessor **19.** The digital Input/Output power supply **90** is isolated and filtered by resistor **91** and capacitor **92.** The digital power supply **90** provides power to memory chip **20.** The resistor **93** and capacitor **94** form an RC network with a time constant of approximately 0.1 second, thereby permitting transients to decay prior to the application of power to RESET terminal **95.** This ensures a clean reset and start of microcontroller **19** into an electrically stable environment. Diode **96** discharges capacitor **94** in the event of a major core power supply **87** transient, thereby providing for a reset of microcontroller **19** if such a transient occurs.

The audio preamplifier **85** is a four stage amplifier with a bandpass filter **97** and with a two bit automatic gain control circuit **98** as specified in the Sensory, Incorporated manual for the RSC-164 Development Kit. When terminals **99** and **100** are set for a high

impedance input, the maximum gain is approximately 59 decibels at the center frequency of 1.49 KiloHertz. This is a gain for a typical application with the microphone about 1.0 to 1.5 feet from the user in a quiet environment. This may vary depending on the ambient environment. The 3 decibel cutoff frequencies are 580 KiloHertz and 4.2 KiloHertz. Resistor **101** supplies the power to a standard two wire electret microphone **10.** The voltage divider resistors **102** and **103** are used to provide the DC bias for amplifier stages **104, 97** and **105,** and it is set to approximately one third of the voltage appearing at terminal **86.** The first stage **104** has a gain of approximately 2.2. The bandpass filter **97** has a gain of approximately 7.8 at the center frequency of 1.49 KiloHertz. The two bit AGC circuit **98** is a programmable voltage divider consisting of Capacitor **106,** resistor **107,** resistor **108,** resistor **109,** resistor **110,** and capacitor **111.** In order to prevent DC level shifts in response to AGC changes, the AGC circuit **98** is AC coupled by capacitor **106** and capacitor **111.** The AGC input control signals appearing at terminals **99** and **100** may independently be either at ground or at high impedance, giving four different levels of attenuation. The gain ratios for the AGC circuit **98** are 1.0, 0.36, 0.18 and 0.13. The third stage amplifier **105** has a gain of 6.6, while the fourth stage amplifier **112** has a gain of 8. Resistors **113** and **114** provide adequate output bias current to prevent crossover distortion between third stage amplifier **105** and fourth stage amplifier **112.** Both of the output terminals **115** and **116** are AC coupled and then DC biased such that at full swing the negative peak voltage goes below zero volts DC (analog ground) at the the inputs of speech recognition microcontroller **19.**

There are several pushbuttons attached to the microcontroller **19** digital Input/Output ports **156, 157, 158** and **159.** For example, a momentary microswitch **160** is activated by pushing a dollar bill into a slot **254** in the box **2.** The switch **160** detects the action of a user paying for their cigarettes. A bellows switch **161** is an alternative method of detecting puffs or inhalations on a simulated cigarette. The bellows switch may also be replaced by a pressure sensor switch which can perform a similar purpose. Sound activated switch **162** , such as described in the Radio Shack catalog No. 276-5011A, is an alternative method of detecting either puffing on a simulated cigarette or coughing.

Similarly, the simulated cigarette can be designed to produce an audible or subaudible whistle tone during puffing. The whistle tone can be sensed by the sound activated switch **162** tuned with a bandpass filter encompassing the whistle tone frequency spectrum. The puff switch sensor can be eliminated by using a sound integrator or sound recognition software. In addition, the pushbutton **163** may be used to activate or wake up the microcontroller **19** when it is in a power saving mode.

The following narrative referring to Figure 5 assumes that the smoking simulator **1** is used in a school environment. The "Teacher" is the person who sets up the device **1** for use by the "Student", and afterwards evaluates the student's performance by commanding the device **1** to produce a recorded report. The various software flowcharts presented here are separated into modules which are functionally distinct from each other. The overview flowchart **169** shows the general relationship between modules, and the logical sequence of the flow of instructions from module to module. Subsequent flowcharts illustrate the inner workings within each module.

In many of the flowcharts there are references to Sensory, Inc's proprietary software subroutines for various speech functions. Rather than explain them each time they are used, they are summarized here. Speaker Verification (SV) subroutines are used for storing and verifying passwords. SV subroutines can distinguish between individual speakers. Speaker Independent (SI) Recognition subroutines are used for recognizing specific commands or responses, no matter who says them. Speech Synthesis (SS) subroutines simply playback a prerecorded word, phrase, or lengthy message. Continuous Listening (CL) Recognition subroutines are used for recognizing specific commands or sounds that may occur at unpredictable times, and must be listened to for an extended period.

The software modules for the smoking simulation **1** are divided into two broad groups. The modules focusing on the teacher's activities start with POWERUP step **170**. The student's activities begin with the RUN module **171**. The teacher's activities

configure the device **1** to recognize his or her passwords, provide the level of challenge they feel is appropriate and, after the simulation is completed, report the results of the student's use of the device **1**. The student's activities include recording their passwords, responding to demands from the device **1** to cough or perform simulated smoking, and listening to extensive educational material. The student also has the option of bumming cigarettes from other students with similar devices **1**. The active operating time of the device **1** is brief compared to the total time it is used, so it spends a large portion of time in SLEEP mode **174** to conserve battery power.

Referring also to Figure 6, when the battery **79** is connected, the microprocessor **19** must perform a "bootup" procedure **172** to properly configure timers, input/output ports, and interrupts. Otherwise they might initialize in a random configuration. Once these basic housekeeping activities are done, the microprocessor runs the applications program for smoking deterrence. There is no on/off or "reboot" switch. Those functions are accomplished by connecting and disconnecting the battery **79**. So each time the battery **79** is reconnected, the software must request and store in step **173** the passwords from the teacher. In the preferred embodiment password security is twofold: (a) the teacher can keep their passwords secret, and (b) the software recognizes in verification step **175** the voice patterns of the individual teacher, so it is difficult for a student to cheat even if they discover the teacher's passwords. The passwords are used to limit access to the subsequent simulation setup steps to the teacher alone. This precaution prevents the student from changing the conditions of the simulation.

A realtime clock, albeit not very accurate (say, plus or minus one hour), is needed to time some events for a specific part of the day. For example, as the exercise progresses to simulate more frequent smoking, the student may be awakened in the middle of the night to have a desperate smoke or have an extended coughing fit. Therefore the software asks for and stores the day and time of the start of the simulation in instruction set **176.** The day is preferred because the software must report the total elapsed time of the simulation, and reporting the starting day and time is easier to understand than reporting

simply the number of hours elapsed. With the realtime clock initialized and running at clock startup step **177**, the device **1** can go to sleep and wait for the teacher to wake it up for further instructions to proceed with the student's portion of the software. Prior to entering sleep mode **174**, device **1** tells the teacher that it is awaiting their signal at prompt step **178**. This notification to the teacher is an attempt to make the device **1** user friendly and self-documenting.

Referring also to Figure 7, the teacher wakes up the device **1** by pushing at interrupt step **180** a wakeup button **179** which can be labelled "Teacher". Upon completing wakeup step **181**, the device **1** will verify that it is indeed the authorized teacher who is responsible for the activation by asking for and verifying the teacher's password at step **173** If password verification fails, the software returns to the step **178** in the POWERUP module to notify the teacher that it is going to sleep to await a valid wakeup call. If the teacher's passwords are correctly verified, the software asks the teacher via request **182** to state one of several commands, such as Report **183**, Run **184**, Buy Cigarettes **185**, Packs Per Day **186**, Escalation Rate **187**, Metabolic Rate **188**, Susceptibility **189**, or Information Frequency **190**. If command recognition fails, the software returns to the step **178** in the POWERUP module to notify the teacher that it is going to sleep to await a valid wakeup call, just as it would if password verification failed. If the teacher commands Report **183**, the device **1** will recite the appropriate measurements of the student's activity with the device **1**. A few examples of data included in the report recitation are elapsed time, number of cigarettes demanded, number of cigarettes consumed, number of delays in responding to demands to smoke, and number of cigarettes borrowed. If the teacher commands Run **184**, the software will jump to the RUN module **171** where the student-related software begins.

The day-to-day monetary cost of smoking is one of its aspects simulated by the device **1**. The device **1** keeps track of an imaginary inventory of cigarettes, decrementing the inventory whenever the student smokes, and incrementing the inventory whenever the

student "purchases" more from the teacher. Therefore, when the teacher commands Buy Cigarettes **185**, the software will ask at step **191** for the teacher to set the number of packs of cigarettes available to the student before more must be purchased. The upper limit is high enough that it is effectively unlimited, in case the teacher does not want a limit. The software has several other variables which can be set by the teacher to tailor the simulation to their needs. The initial level of addiction can be set by commanding an initial smoking rate **192** in packs per day. The teacher also sets the escalation rate **193**, that is, how many days it takes to escalate from one pack per day to two or three or four packs per day. This will often depend on how long the student can keep the simulator before it must be used by someone else, and how rigorous a lesson the teacher wants the student to endure. For example, the medium settings simulates a one pack a day habit on the first day, two packs a day on the second day, and three packs a day on the third day. The student's physiological response to nicotine is simulated by setting two other variables, metabolic rate **194** and susceptibility **195**. These variables are described in the curriculum literature that accompanies the device **1**. In general, these variables are dependent on the student's level of physical activity (active or inactive) and body weight. The rate of educational information **196** recited to the student can also be set by the teacher. If the teacher sets the simulation to last only one day, the goal will typically be to inundate the student with a rapid rate of information **196**. If the simulation is intended to last a week, the information rate **196** may be reduced to a relatively meager rate. After each variable has been set by the teacher, the program returns via path **197** to ask the teacher to give another command. When the teacher finishes setting as many variables as they wish, the teacher will respond to the request for command with silence or a noncommand word. The software will then return to idling step **178** in the POWERUP module and notify the teacher that the device **1** is going to sleep.

Referring also to Figure **8**, the RUN module **171** is an "Executive" routine because it performs calculations, checks lookup tables, and otherwise makes decisions that affect the course of events throughout the student's use of the device **1**. Most of the other modules in device **1** merely respond to calls from interrupts or from the RUN

module **171**. The RUN module **171** is the only module that makes activity scheduling decisions. Throughout the simulation, the device **1** will make demands of the student, await the student's response, and measure and record that response for eventual reporting to the teacher. Each time the student responds to a demand, the device **1** will verify that the response is coming from the correct student (the student to which device **1** was assigned). This keeps the students honest and prevents them from giving the device to, for example, a little brother, to play with. An added benefit is that when the student knows they cannot cheat, they pay closer attention.

To enable verification of the student's identity, the device **1** as a first step **198** records a student's password. The verification step **198** of the software can only be accessed immediately after the teacher executes Run command **184**, so the teacher will be present to ensure that the designated student records their voice-dependent password. Once this is done, the student cannot access verification step **198**. The passwords can only be changed by the teacher, using their own passwords, or by removing the battery **79**, which is detectable by the teacher since it will affect the realtime clock **177** as well as the teacher's passwords.

The student is given some choices to tailor the simulation to their personal preferences, which will hopefully give the student a geater interest in the results. First the student selects at step **199** a brand of cigarettes. Each brand will have its own market appeal, cost, nicotine content, and carcinogenic effect, which will be recorded in the device's memory **20**, and will be used in calculations that follow. The student next chooses a personality **200** for their device. The personality **200** traits apply to only a few of the messages from the device **1**, but are hopefully frequent enough to keep the student interested and paying attention. Personality **200** traits include Humorous, Sarcastic, Motherly, Scientific, Suggestive, Teenage or Random.

The core of the simulation scheduling software resides in the next two steps **201** and **202** which calculate the realistic physiologic effects on the student of the simulated

nicotine addiction defined by the values the teacher has previously set for the simulation variables. This includes calculation **201**, using equations from actual pharmacokinetic studies, of the student's simulated blood nicotine content using variables such as: (a) how long ago did they last smoke a cigarette, what brand of cigarette was it (nicotine contents vary), how fast did they smoke it, and how completely did they smoke it, (b) how fast do they metabolize nicotine, (c) what is their physiologic succeptibility to blood nicotine level, and (d) what time of day is it (metabolic rates vary).

From these physiological calculations **201**, the software will assign a simulated nicotine craving level **202** to the student. This craving level **202** ranges from mild agitation through many levels of anxiety and irritability all the way up to immobilizing nausea. This craving level **202** will be communicated to the student in several ways: (a) Demands for a smoke, (b) Nicotine level warnings, (c) General information and factoids, (d) Detailed descriptions of how they would feel and demands for how they should act, (e) Random and escalating nagging, and (f) General advice and guidance. Based on the student's simulated craving level **202**, the software will decide by using a series of lookup tables the appropriate level of intensity of educational messages at any given time during the simulation, and select the addresses within electronic memory **20** of the messages to playback to the student. In the extreme case where a student excessively delays smoking to the point of withdrawal, and the long delayed cigarette is finally smoked, the software could demand a vomiting episode in which the student must make a retching noise that the software can recognize. That particular activity is scheduled in the nicotine craving level step **202**, although it is actually performed in the SMOKING ACTION module **203**.

As the simulation progresses to higher levels of addiction and more frequent smoking, the calculated physiologic effects **201** will escalate, and the simulated damage to the student's lungs will accumulate. Part of this calculation is based on the carcinogenic effect of the cigarette brand chosen by the student. As a result, the device **1** will demand more frequent and more severe coughing fits from the student, eventually to

the point of waking the student up in the middle of the night to cough, smoke, and cough some more.

Other information that may be calculated and communicated to the student includes pulse rate variations, lung capacity reduction, blood pressure increase, stress on the heart, and other diseases or conditions to which smokers may be susceptible because of their smoking. The software will update the value of a "Deathclock" that measures the expected minutes/days/years of lifespan lost assuming that the current trend of simulated smoking proceeds unchecked. The deathclock is calculated by nicotine craving level block **202** but reported in the SMOKING ACTION module **203**, immediately after the student smokes, to give the student immediate feedback on the long term consequences of their smoking.

Once the nicotine craving block **202** has calculated what messages regarding smoking, coughing, and educational information should be communicated to the student, and when they should be communicated, the software will setup internal timers **204** to wake itself up at the appropriate times. The device **1** will go to sleep and wait for those interrupts. Once asleep device **1** will also respond to pushbutton interrupts from either the student or the teacher.

Referring also to Figure 9, the smoking notification module **205**, which is called by the RUN module **171**, simply notifies the student that it is time to smoke. The student must respond via the Student Pushbutton **163** before simulating smoking. Simulated smoking is processed by the SMOKING ACTION module **203**. The device **1** has three notification methods **206** of notifying the student that it is time to smoke. There is a pager-type vibrator that the student can feel if the device is in their pocket. There is a beeper-type beep that the student can hear if the device is in their purse or if they are asleep. Finally, after a short pause, there is a spoken demand for smoking. After notifying the student, the device scheduler **207** sets the next notification for five minutes in the future. This ensures an irritating nagging process for as long as the student puts off

smoking. Then the software returns to calculator **201** and nicotine craving block **202** in the RUN module **171** to recalculate the student's simulated nicotine level and craving level based on the extra time elapsed, and then returns to sleep mode **174**.

As seen in Figure 11, the Information Notification module **208**, which is called by the RUN module **171**, simply notifies the student that it is time to listen to educational information. The student must respond via the Student Pushbutton **163** before listening to the information. The device **1** has three methods **209** of notifying the student that it is time to listen to information. There is a pager-type vibrator that the student can feel if the device is in their pocket. There is a beeper-type beep that the student can hear if the device is in their purse. And finally, after a short pause, there is a spoken demand for the student to listen to information. After notifying the student, the device **1** sets the notification timer **210** for five minutes in the future. This ensures an irritating nagging process for as long as the student puts off listening to the information. Then the software returns to the calculatior **201** in the RUN module **171** to recalculate the student's simulated nicotine level, craving level and message intensity level based on the extra time elapsed. The device **1** then enters sleep mode **174.**

As seen in Figure 14, the COUGHING INTERRUPT module **211**, called by the RUN module **171**, both notifies the student that it is time to cough, and monitors whether they do or do not cough. This action cannot be delayed, only passed or failed. The Student Pushbutton **163** is neither required nor active when module **211** is active.
The device **1** has three methods **212** of notifying the student that it is time to cough. There is a pager-type vibrator that the student can feel if the device is in their pocket. There is a beeper-type beep that the student can hear if the device is in their purse. And finally, after a short pause, there is either a spoken demand for coughing or loud playback of a recorded cough. In order to wake up students in the middle of the night, the device **1** may playback a coughing fit rather than a spoken demand. After notifying the student, the device **1** initiates verification step **198** by asking for the student's passwords, thereby making sure that the right student will be coughing.

The RUN Executive routine **171** will pass a parameter to coughing module **211** specifying the demanded intensity of the coughing episode. The parameter may specify anything from a single hack to an extended coughing fit. The coughing module **211** will at cough prompt **213** ask for, listen for, and recognize the student coughing some specified number of times. If the student fails to cough appropriately, the device will give them the option **214** to try again. Their success **215** or failure **216** will be noted before returning to the RUN module **171** for recalculations **201** and the return to sleep mode **174**.

After the student has been notified that the device demands either smoking or information playback, the student can press the Student pushbutton **163** to indicate that they are ready to perform the demanded action. This wakes the device **1** up from the sleep mode **174**. After awakening, the device **1** asks for and verifies at step **198** the student's passwords to make sure that the correct student has awakened the device **1**. Next, the device **1** asks for the student's command **217** to either smoke, bum cigarettes, or playback educational information. At this point, depending on student delays, random chance generator **218**, and recognition by the software of extraneous epithets, the software may select belligerence path **219**. For example, the software may randomly tell the student that they are out of matches. If the software follows belligerence path **219**, repetition step **220** will tell the student to try again later, or issue a similarly appropriate message. If the software cooperates with the student via cooperation path **221**, as it most likely will, then the program returns to either the smoking action module **203**, bumming module **222**, or information playback module **223**.

Referring also to Figure 16, the smoking procedure **203** begins with an internal check **224** to see if there are any simulated cigarettes remaining in inventory. If not, the device **1** will so inform the student via announcement **225** and then return to the RUN module **171** for recalculations **201** and sleep **174**. From the RUN module **171** the student

can either wake the device and bum a cigarette from another student via module **222**, or "buy" cigarettes from the teacher. If there are cigarettes remaining, the device will execute announcement **226** and tell the student to "Puff away", then enter a Continuous Listening subroutine **227** to listen for puffs at variable intervals.

When each puff is recognized, the consumption rate step **228** will calculate how much of the cigarette has been smoked. This calculation **228** will include the intensity and duration of the puff as well as the interval since the last puff. If the cigarette is not done, the program will follow return path **229** to subroutine **227** and listen for another puff. If this was the first puff occurring after nicotine withdrawal as calculated by counter **230**, the program will execute demand **231** for a retching sound from the student. After the retch is recognized the device **1** will tell the student, via message bank **232** a message chosen by random message generator **233** such as "You just barfed on your lit cigarette. You must smoke another, after washing your hands." or "Barf into a toilet, then flush the toilet". The device **1** will listen for and recognize via sound monitor **234** the sound of the toilet flushing. If no puff is heard at step **227**, the software will continue to ask the student if they wish to try again **235**. If not, the software will record a failure **236** and return to the RUN module parameter calculator **201.**

When the cigarette is done there may be another randomly generated smoking event **233** such as the device **1** saying, for example, "You burned your fingers! Scream out loud!" or "You burned a nearby piece of furniture. Put a stickon burn decal on a nearby piece of furniture". After a pause, the device **1** enables deathclock monitor **237** and says "Done" and reads out the value of the Deathclock. The software records the accumulated duration and intensity of puffs from this cigarette at recorder **238** for use by the RUN module in recalculating blood nicotine level at calculator **201**. Then the cigarette inventory **239** is decremented, and the software returns to the RUN module for recalculation **201** and sleep **174**.

Students must perceive this overall simulation device **1** as realistic in order to embrace and make the most of the educational experience. Borrowing or "bumming" cigarettes is a realistic feature of the device **1** intended to encourage active communication among students. As best understood by reference to Figure **17**, if two students with similar devices **1** agree that one will allow the other to bum a cigarette from him, then the two of them will simultaneously wakeup their devices **1** and command them to enable the bum cigarettes module **222**.

Each device **1** will ask its student whether they choose to give or receive a cigarette at question **240.** The donating device **1** will check its inventory to ensure that it has cigarettes to give. If there are none, device **1** will inform the student along failure path **241** and return to RUN module step **201** and sleep mode **174**. If the device **1** does have cigarettes to give, device **1** will listen **242** for a unique "Receiving" tone from the other device **1** asking for a cigarette. When the software recognizes **243** the "Receiving" tone device **1** will immediately playback **244** a unique "Given" tone (actually a secret composite tone so it is difficult to counterfeit) for a few seconds. Then the software will decrement **245** its inventory of cigarettes and return to the RUN module **201** and sleep mode **174**

.

The "Receiving" device **1** will begin a loop **246**, lasting a maximum of ten seconds, during which loop **246** will alternately playback the "Receiving" tone for half a second, then listen for half a second for the "Given" tone of acknowledgement from the other device **1**. Once device **1** recognizes **247** the "Given" tone, the software increments **248** its inventory and returns to the RUN module **201** and sleep **174**.

The total number of cigarettes given and received is recorded and reported to the teacher so that cheating (e.g. bumming one cigarette to multiple receivers simultaneously, or tape recording the "Given" tone) can be easily detected. One can eliminate cheating by embedding a unique two-way code in the transmitted tones, or by requiring one-to-one physical connection between devices for communications. Typically, the device's added

complexity and cost are not warranted since occasional counting by the teacher will suffice to deter cheating.

There are many methods of communicating between devices for bumming cigarettes. As a passive example, one might install contacts on each box connected to a 100K ohm resistor. When the devices are touched together in parallel, the resistance drops to 50K ohm. The microcontroller **19** can measure this resistance reduction. As an active example, the students might touch together contacts on the devices while pushing appropriate buttons. The preferred approach adds no hardware or software beyond that which already exists for tone playback and recognition.

As best seen in Figure 18, every piece of educational information that is recited by the device **1** ends with a true/false or yes/no question **249**. Listening interval **250** begins thereafter to determine if the student has answered the question **249.** The student must give the correct answer **251** to the question **249** in order to prevent the information from being repeated at some later time. The software records whether the question was answered correctly at register **252** or incorrectly at register **253** before returning to the RUN module for recalculation **201** and sleep mode **174**.

As those skilled in the art will appreciate, the simulator **1** can be equipped with a variety of different programs with different timings, information, and curriculum depending on whether the device **1** is simulating, for example, smoking tobacco, marijuana, ingesting cocaine, or injecting other drugs.